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MEMORANDUM REPORT ARLCB-MR-83036

COLD ROTARY FORGING OF A THIN-WALLED RIFLED TUBE

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OCTOBER 1983

US ARMY ARMAMENT RESEARCH AND DEVELOPMENT CENTER
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In Technical Report WVT-TR-75054 on cold rotary forging of rifling into a thin-wall gun tube, it was stated that the yield strength of the forged material increased in the longitudinal direction, while a recoverable loss was observed in the tangential (hoop) direction.

A recently obtained metallographic study of the same material suggests a potential improvement in fatigue life and/or fracture toughness of the material, attained in that earlier work but overlooked at the time.

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TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

INTRODUCTION

Campione, Liuzzi, and Heiser, in Technical Report WVT-TR-75054[1] described a preliminary study of introducing rifling into a thin-wall gun tube while simultaneously rotary forging the outer surface. This was achieved through the use of a rifled mandrel at the inside of the tube during the forging operation. As a way of reducing manufacturing costs, they emphasized finish forming the internal rifled configuration, thereby eliminating the subsequent machining operation. The effect of this forging process on the mechanical properties and residual stresses of the material being used was also described.

DISCUSSION

Dimensionally the results showed a slight departure in the forged tube's I.D. (at the grooves as well as at the lands) as compared to the mandrel. This was anticipated and was justifiably attributed to material spring-back. The authors also encountered a departure in the forged tube's land width from that of the mandrel's groove, and likewise attributed it to material spring-back. Material spring-back is limited to $\varepsilon = \sigma_e/E$, where $\sigma_e \equiv$ material's elastic limit and $E \equiv$ material's Modulus of Elasticity. In the case at hand, with material yield strength not exceeding 160,000 psi this would amount to a maximum spring-back of 0.53 percent, whereas the reported departure in land width varies between 5 percent and 10.6 percent. It is suggested here that

[1]Alfred A. Campione, Leonard Liuzzi, and Francis A. Heiser, "Cold Rotary Forging," Watervliet Arsenal Technical Report WVT-TR-75059, Watervliet, NY, September 1975.

the reduced land width results from axial flow of the material through helical grooves during forging. The axial flow causes land width to narrow through deformation or wear on one side. This suggestion is supported by the roughly linear correlation between the amount of deformation reduction and percent loss in land width. Nevertheless, once the mechanism is known, we can conclude that with further work the stringent dimensional requirement can be achieved.

An increase in yield strength after forging was noticed in the axial direction. In the tangential (hoop) direction, Campione et al[1] reported reduction in yield strength after deformation. However, these losses in yield strength in the hoop direction were recovered after heat-treatment. They also reported that a closer examination of the rifling grooves revealed no longitudinal score marks, tears or gouges, which are commonly found in rifling grooves that are produced by conventional machining methods such as solid rifling broaches and individual rifling cutting. They presumed that the surface stress concentration may be reduced substantially. These surface stress concentrations are limited to an extremely thin layer at the surface. This investigator believes that of greater importance is the difference in texture structure at and below the surface. In the broached rifling the prebroaching texture structure, if any, is being cut through, with metallurgical irregularities sometimes being normal to the surface (see Figure 1). These are often nucleation sights for fatigue failure. Because in the

[1]Alfred A. Campione, Leonard Liuzzi, and Francis A. Heiser, "Cold Rotary Forging," Watervliet Arsenal Technical Report WVT-TR-75059, Watervliet, NY, September 1975.

forged tube (Figure 2) the texture structure is parallel to the surface, it is less prone to fatigue failure nucleation. Tensile and impact tests were made on machined specimens where the surface texture referred to here was removed. Accordingly, a potential advantage thereof did not receive its deserved attention. However, it has been reported that the service life for the small caliber tubes was extended when they were rotary forged. Texturizing due to the rotary swage operation in the longitudinal direction, both at the land and under the groove, is shown in Figure 3.

CONCLUSIONS

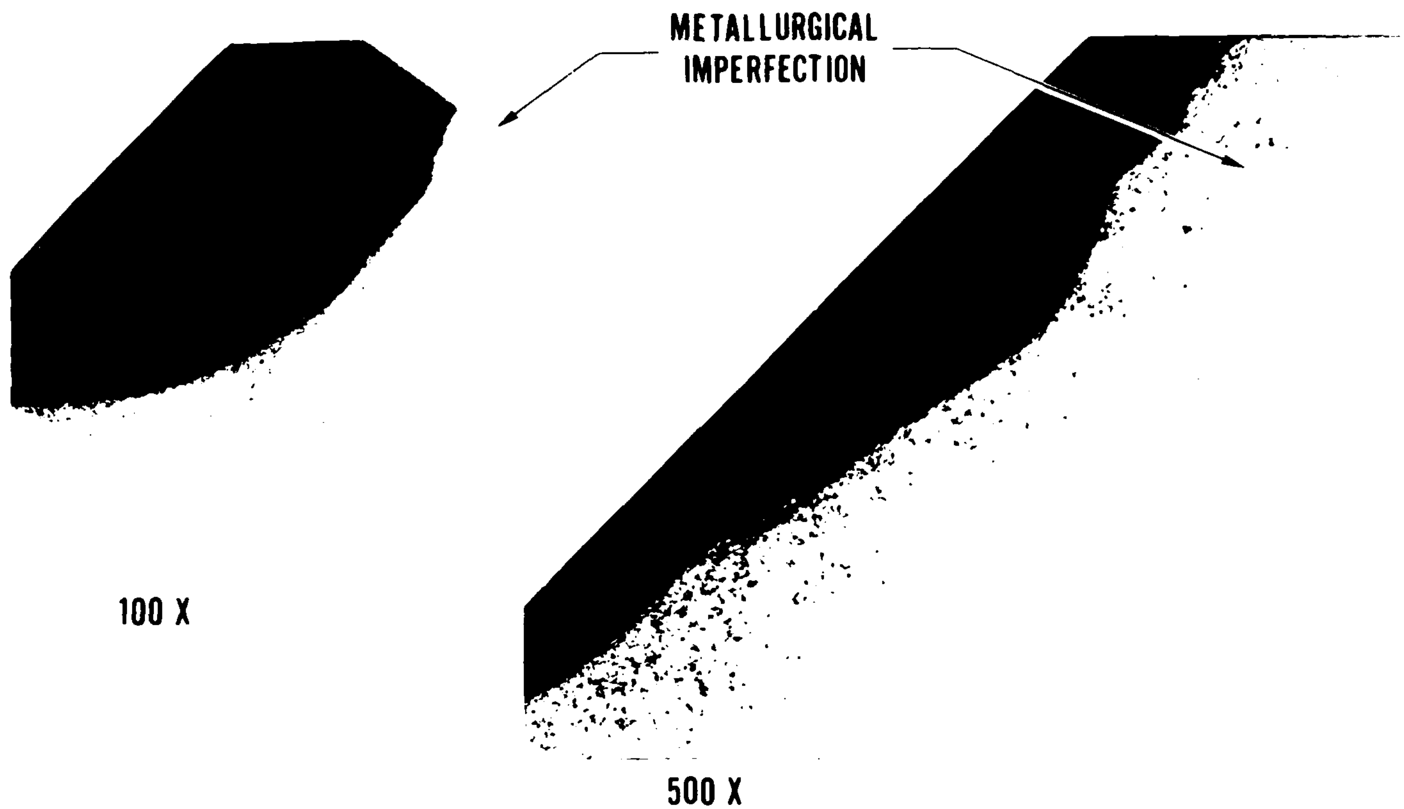
One may conclude that plastically deforming the rifling while simultaneously rotarty forging the tube is limited to thin-wall tubes and that its economical advantage over post-deformation broaching is in reducing the manufacturing cost. However, even if the tube's wall thickness is a limiting factor in incorporating the rifling with rotary forging, there are other methods for plastically deforming the rifling into the tube. These methods are not confined to thin-wall tubes. One should not overlook the benefits of improved fatigue life and/or fracture toughness, which may lead to longer service life, reduced tube weight, and/or increased propelling pressure with all of its consequences.

REFERENCES

1. Alfred A. Campione, Leondard Liuzzi, and Frances A. Heiser, "Cold Rotary Forging," Watervliet Arsenal Technical Report WVT-TR-75059, Watervliet, NY, September 1975.

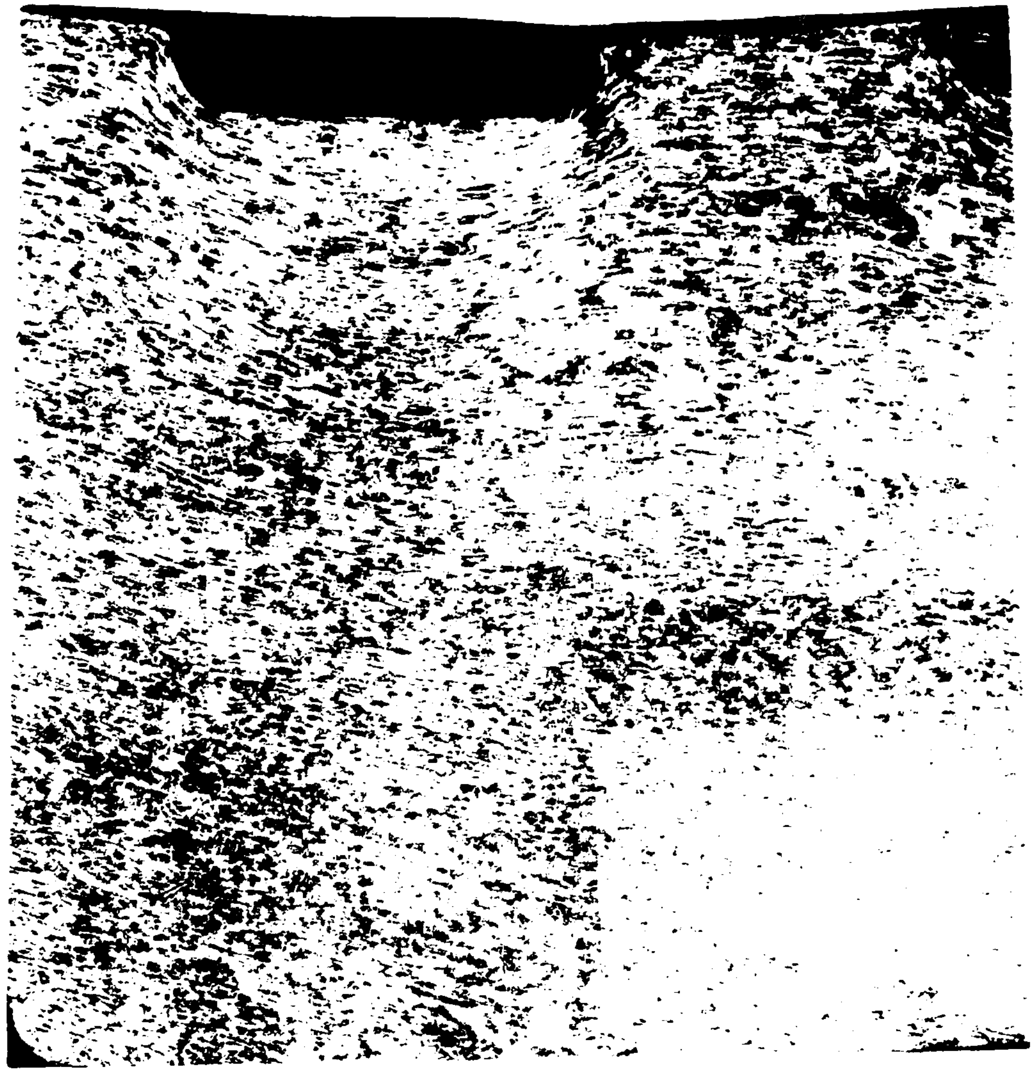
BROACHED RIFLING IN 105mm GUN TUBE
TRANSVERSE, 20 X

FIGURE 1(a)



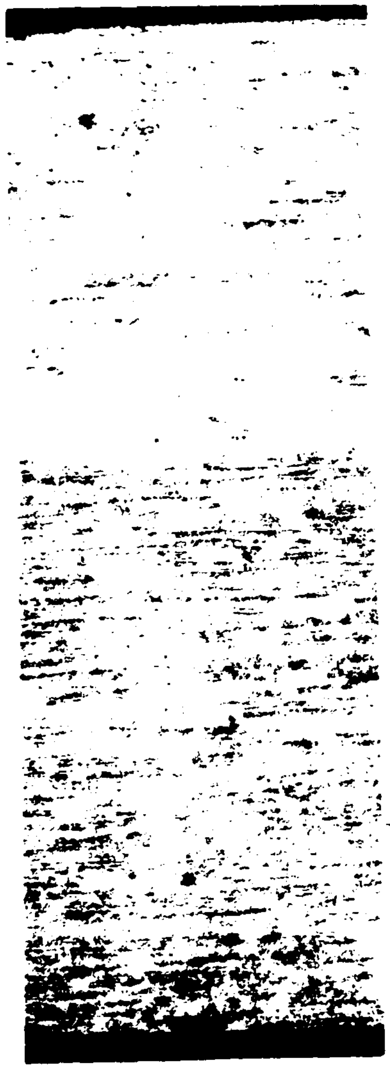
BROACHED RIFLING IN 105mm GUN TUBE
TRANSVERSE, METALLURGICAL IMPERFECTION
AT THE ROOT OF THE LAND

FIGURE 1(b)



FORGED RIFLING [illegible] UBE
TRANSVE[illegible], 20 X

FIGURE 2



FORGED RIFLING
IN 105mm GUN TUBE
LONGITUDINAL, 20X

THROUGH GROOVE

THROUGH LAND

FIGURE 3

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